

WHAT IS CLAIMED IS:

1. A thermoplastic elastomer having A blocks and B blocks and being present in a substantially solid state suitable for use as a binder for at least one of a propellant, explosive, and gasifier, the thermoplastic elastomer being formulated from a composition comprising, as constituents:

A blocks terminated with isocyanate-reactive groups derived from monomers comprising at least one member selected from the group consisting of oxetane derivatives and tetrahydrofuran derivatives, the A blocks being crystalline at temperatures below about 75°C;

B blocks terminated with isocyanate-reactive groups derived from monomers comprising at least one member selected from the group consisting of oxetane and derivatives thereof, tetrahydrofuran and derivatives thereof, and oxirane and derivatives thereof, the B blocks being amorphous at temperatures above about -20°C; and

linking groups derived from at least one diisocyanate for end-capping the A blocks and the B blocks and at least one difunctional oligomer comprising two functional groups which are reactive with isocyanate moieties of the diisocyanate.

2. A thermoplastic elastomer as defined in claim 1, wherein:

the diisocyanate contains a first isocyanate moiety which is at least five times more reactive with the terminal groups of the blocks than a second isocyanate moiety thereof, whereby the more reactive first isocyanate moiety is capable of reacting with and end capping the terminal groups of the blocks, leaving the less reactive second isocyanate moiety free and unreacted; and

the difunctional oligomer has two isocyanate-reactive hydroxyl groups which are sufficiently sterically unhindered to be reactive with the free and unreacted second isocyanate moieties of the end-capped blocks.

3. A thermoplastic elastomer as defined in claim 2, wherein the diisocyanate comprises toluene diisocyanate.

4. A thermoplastic elastomer as defined in claim 1, wherein the A blocks are crystalline at temperatures below about 60°C.

5. A thermoplastic elastomer as defined in claim 1, wherein the difunctional oligomer comprises a reaction product of at least one diol and at least one diisocyanate, the diol being selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, and 1,4-cyclohexanedimethanol, and any
5 combination thereof.

6. A thermoplastic elastomer as defined in claim 1, wherein the difunctional oligomer comprises a reaction product of at least one diol and at least one diisocyanate, the diisocyanate being selected from the group consisting of hexane diisocyanate, methylene-bis(4-phenyl isocyanate), phenylene diisocyanate, toluene
10 diisocyanate, and xylylene diisocyanate, and any combination thereof.

7. A thermoplastic elastomer as defined in claim 1, wherein the thermoplastic elastomer has a weight average molecular weight of at least 40,000 and a number average molecular weight of at least 10,000.

8. A thermoplastic elastomer as defined in claim 1, wherein the
15 thermoplastic elastomer has a weight average molecular weight of at least 60,000 and a number average molecular weight of at least 12,000.

9. A thermoplastic elastomer as defined in claim 1, wherein the thermoplastic elastomer has a weight average molecular weight of at least 80,000 and a number average molecular weight of at least 15,000.

20 10. A thermoplastic elastomer as defined in claim 1, wherein a weight ratio of A to B blocks is between about 15:85 to about 40:60.

11. A thermoplastic elastomer as defined in claim 1, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

25 12. A binder comprising:
about 50 wt% to about 95 wt% of at least one solid selected from the group consisting of fuel material particulates and oxidizer particulates; and
at least one thermoplastic elastomer having A blocks and B blocks and being present in a substantially solid state to immobilize the particulates, the thermoplastic elastomer being formed from a composition comprising, as constituents:

A blocks terminated with isocyanate-reactive groups derived from monomers comprising at least one member selected from the group consisting of oxetane derivatives and tetrahydrofuran derivatives, the A blocks being crystalline at temperatures below about 75°C;

5 hydroxyl-terminated B blocks terminated with isocyanate-reactive groups derived from monomers comprising at least one member selected from the group consisting of oxetane and derivatives thereof, tetrahydrofuran and derivatives thereof, and oxirane and derivatives thereof, the B blocks being amorphous at temperatures above about -20°C; and

10 linking groups derived from at least one diisocyanate for end-capping the blocks and at least one difunctional oligomer comprising two functional groups which are reactive with isocyanate moieties of the diisocyanate.

13. A binder according to claim 12, wherein:

15 the diisocyanate contains a first isocyanate moiety which is at least five times more reactive with the terminal groups of the blocks than a second isocyanate moiety thereof, whereby the more reactive first isocyanate moiety is capable of reacting with and end capping the terminal groups of the blocks, leaving the less reactive second isocyanate moiety free and unreacted; and

20 the difunctional oligomer has two isocyanate-reactive hydroxyl groups which are sufficiently sterically unhindered to be reactive with the free and unreacted second isocyanate moieties of the end-capped blocks.

14. A binder as defined in claim 12, wherein the A blocks are crystalline at temperatures below about 60°C.

25 15. A binder as defined in claim 12, wherein the difunctional oligomer comprises a reaction product of at least one diol and at least one diisocyanate, the diol being selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, and 1,4-cyclohexanedimethanol, and any combination thereof.

30 16. A binder as defined in claim 12, wherein the difunctional oligomer comprises a reaction product of at least one diol and at least one diisocyanate, the diisocyanate being selected from the group consisting of hexane diisocyanate,

methylene-bis(4-phenyl isocyanate), phenylene diisocyanate, toluene diisocyanate, and xylylene diisocyanate, and any combination thereof.

17. A binder as defined in claim 12, wherein the solid is at least one member selected from the group consisting of aluminum particulates, ammonium perchlorate, and ammonium nitrate.

18. A binder as defined in claim 12, further comprising at least one member selected from the group consisting of cyclotetramethylene tetranitramine (HMX), cyclotrimethylene trinitramine (RDX), 2,4,6,8,10,12-hexanitro-2,4,6,8,10,12-hexaazatetracyclo[5.5.0.0^{5,9}.0^{3,11}]-dodecane (CL-20), and 4,10-dinitro-2,6,8,12-tetraoxa-4,10-diazatetracyclo[5.5.0.0^{5,9}.0^{3,11}]-dodecane (TEX).

19. A binder as defined in claim 12, further comprising at least one energetic plasticizer selected from the group consisting of glycidyl azide polymer (GAP), nitroglycerine, butanetriol trinitrate (BTTN), alkyl nitratomethyl nitramines, trimethylolethane trinitrate (TMETN), diethylene glycol dinitrate, triethylene glycol dinitrate, and bis(dinitropropylacetal/-bis(dinitropropyl)formal (BDNPA/F).

20. A binder as defined in claim 12, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

21. A rocket motor propellant comprising the binder of claim 12.

22. A gun propellant comprising the binder of claim 12.

23. An explosive comprising the binder of claim 12.

24. A gasifier comprising the binder of claim 12.

25. A method of preparing a thermoplastic elastomer having A blocks which are crystalline at temperatures below about 75°C and the B blocks which are amorphous at temperatures above about -20°C, the method comprising:

providing A blocks and B blocks at approximately the stoichiometric ratios that are intended to be present in the thermoplastic elastomer, the A blocks being terminated with isocyanate-reactive functional groups, crystalline at temperatures below about 75°C, and derived from monomers comprising at least one member

selected from the group consisting of oxetane derivatives and tetrahydrofuran derivatives, the B blocks being terminated with isocyanate-reactive functional groups, amorphous at temperatures above about -20°C, and derived from monomers comprising at least one member selected from the group consisting of oxetane and derivatives thereof, tetrahydrofuran and derivatives thereof, and oxirane and derivatives thereof;

end-capping the A blocks and the B blocks by reacting the A blocks and B blocks with at least one diisocyanate in which a first isocyanate moiety thereof is at least about five times more reactive with the terminal groups of the blocks than a second isocyanate moiety thereof, whereby the more first reactive isocyanate moiety is capable of reacting with the terminal groups of the blocks, leaving the less reactive second isocyanate moiety free and unreacted; and

linking the end-capped A blocks and the end-capped B blocks together with a difunctional oligomer comprising two isocyanate-reactive groups which are sufficiently sterically unhindered to react with the free and unreacted second isocyanate moieties of the end-capped polymers.

26. A method as defined in claim 25, wherein the diisocyanate comprises toluene diisocyanate.

27. A method as defined in claim 25, wherein the A blocks are crystalline at temperatures below about 60°C.

28. A method as defined in claim 25, further comprising preparing the difunctional oligomer by reacting at least one diol and at least one diisocyanate, the diol being selected from the group consisting of ethylene glycol, propylene glycol, butylene glycol, and 1,4-cyclohexanedimethanol, and any combination thereof.

29. A method as defined in claim 25, further comprising preparing the difunctional oligomer by reacting at least one diol and at least one diisocyanate, the diisocyanate being selected from the group consisting of hexane diisocyanate, methylene-bis(4-phenyl isocyanate), phenylene diisocyanate, toluene diisocyanate, and xylylene diisocyanate, and any combination thereof.

30. A method as defined in claim 25, wherein the isocyanate-reactive terminal groups of the A and B blocks are hydroxyl groups.

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